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KNOWLEDGE FRAMEWORK BUILDING OF "CHEMICAL PROCESS AND EQUIPMENT" COURSE

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ABSTRACT

This paper aims at research and building a knowledge framework aiming at "Chemical Process and Equipment" course, which is fit for graduate students specialized in chemical and related specialties and with poor knowledge of Chemical Engineering. The framework was built and contents mainly included: characteristics of chemical industry; differences and relations of lab study and chemical industry; significance of chemical engineering design and its common program; typical chemical engineering unit operations and equipment; method of chemical engineering design and calculation; type of flow diagram and designing software; instances of typical chemical technology. Several years of practice proved that the knowledge framework was in favor of the grasp and application of the basic knowledge and methods.

KEYWORDS: Chemical Process and Equipment, Knowledge framework, Teaching content, Optimizing.

1. INTRODUCTION

"Chemical Process and Equipment" is a curriculum of high complexity and high-demanding practice. It's difficult for chemical and related specialty postgraduates who are poor in basic knowledge of Chemical Engineering. It's necessary to optimize the course structure and set up rational knowledge frame in order to help students realize the importance of course study, and grasp basic concepts and methods, which presents as chemical engineering unit operation, material balance calculation, heat balance calculation, chemical process flow. The main experiences and results were stated in the followings in detail.

2. BUILDING OF THE KNOWLEDGE FRAMEWORK

Based on the curriculum requirement, students' knowledge reserve and the author's teaching experience, the content framework of "Chemical Process and Equipment" course was established and showed as Figure 1.

3. THE IMPLEMENTING EMBODIMENT

3.1 THE SIGNIFICANCE OF CHEMICAL ENGINEERING DESIGN AND ITS ESSENTIAL PROGRAM

In this part, the main teaching content includes:

(1) Characteristics of chemical industry

In teaching, the preparation of sulfuric acid by pyrite was used to illuminate the complexity of chemical production process (Gong, 2013).

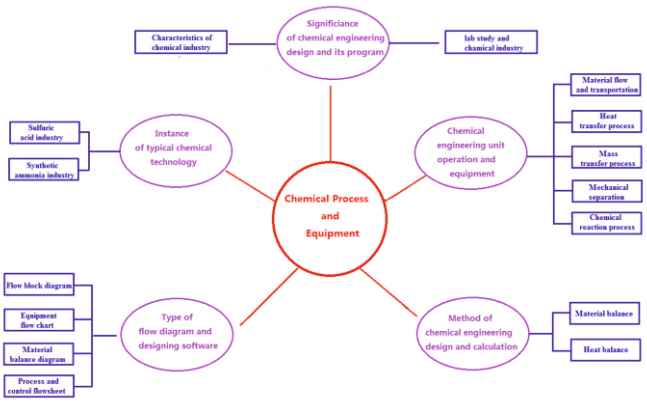

Figure 1 The knowledge framework of "Chemical Process and Equipment" course

(2) Differences and relation of lab study and chemical industry

Differences between experimental approach and chemical industry for the synthesis of ***phthalic anhydride*** as per equation (1) were discussed, and it was meant to prove the differences of: I. different dosage of reactants and catalyst; II. different heating mode and reaction temperature control means; III. different product separation, purification and collection method; IV. different transport mode for material and product.

$$naphthalene + oxygen \xrightarrow{V_2O_5} phthalic\ anhydride + Q_{re} \quad (1)$$

(3) Significance of chemical engineering design and the design program

Base on the difference of lab study and chemical process, and combination the complexity of chemical industry, it shows the necessity and importance of chemical engineering design. To insure the scientificity, economic efficiency and rationality, design should follow the three-step order of **feasibility study, preliminary design** and **working drawing design** (Lou, 2002).

Homework: Illustrate the characteristics of chemical industry basing on one kind of product producing process.

3.2 CHEMICAL ENGINEERING UNIT OPERATION AND EQUIPMENT (Lv, 2015; Wuhan University, 2001; Wang, 1992)

The involving unit operations and equipment were listed as follows.

(1) Fluid flow and material transportation

I. Momentum transport theory of fluid

II. Equipment:

Liquid transfer equipment: centrifugal pump, reciprocating pump, wheel pump

Gas delivery equipment: ventilator, blast blower, compressor, vacuum pump

Solid carrying equipment: lifting platform, forklift, belt conveyor, pneumatic conveying system, feeder hopper

(2) Heat transfer process

I. Heat transport theory

II. Equipment:

Heat exchanger classified by heat exchange mode: direct mixing heat exchanger, between wall heat exchanger, energy storage heat exchanger

Heat exchanger classified by predominant use: heater, cooler, evaporator, condensator, reboiler, air cooler

(3) Mass transfer process

I. Mass transport theory

II. Equipment

Evaporation: standard vertical tube evaporator, basket type evaporator, liewen evaporator, pumpfeed evaporator, climbing film evaporator, falling film evaporator

Distillation: bubble-cap tower, valve tower, sieve-plate tower. The typical stuffing in packed tower: rasching ring, pall ring, hommel, cascade ring, ripple packing

Arefaction: heat conduction dryer, heat convection dryer

Absorption: rasching ring packed tower, pall ring packed tower, hommel packed tower, cascade ring packed tower, ripple packing packed tower

Extraction: liquid-liquid extraction, solid-liquid extraction, supercritical extraction and extraction equipment of extractor, extraction tower, leacher

(4) Mechanical separation

I. Principle

II. Equipment

Gravitational sedimentation: gravity settling tank, dust settling chamber

Centrifugal sedimentation: cyclone separator, cyclone hydraulic separator, centrifuge

Filtration: plate-and-frame press, leaf filter, rotary drum vacuum filter

Sieving: fixed screen, vibrating screen, roller screen

(5) Chemical reaction process
I. Principle
II. Equipment
Reactor of intermittent operation: batch stirring tank reactor

Reactor of continues operation: homogeneous reactor (continuous stirring tank reactor, tube reactor), heterogeneous reactor (fixed-bed reactor, fluidized-bed reactor, moving-bed reactor)

Homework: Illustrate the involved chemical engineering unit operations, their principle and equipment basing on one kind of chemical product production.

3.3 METHODS OF CHEMICAL ENGINEERING DESIGN AND CALCULATION

Material balance: the calculation based on equation (2) for the continuous process and equation (3) for the batch process.

$$\sum F_{in} - \sum F_{out} - \sum F_{reacted} = \frac{dm}{dt} \quad (2)$$

$$\sum m_{in} - \sum m_{out} - \sum m_{reacted} = dm \quad (3)$$

Heat balance: the calculation based on equation (4).

$$\sum Q_{in} - \sum Q_{out} + \sum Q_{heat-carrier} + \sum Q_{reaction-heat} = dQ \quad (4)$$

Homework: Give an example of material balance or heat balance and discuss it in class.

3.4 TYPE OF FLOW DIAGRAM AND DESIGN SOFTWARE

In this part, the main teaching content includes:

(1) Composition of normal chemical technological process

(2) Design procedure of chemical technological process

(3) Classification: flow block diagram, equipment flow chart, material balance diagram, process and control flow sheet (working drawing), utility system diagram.

(4) Drawing requirements

(5) The normal used software: Aspen Plus of America Aspen Tech; ChemCAD of America Chemstations; Design II of America WinSim Inc.; gPROMS of England PSE; VMGSIM of Canada Virtual Materials Group; ECSS of China Qingdao Chemical Engineering Institute.

Homework: Describe one kind of product producing process with suitable form of process flow diagram.

3.5 INSTANCE OF TYPICAL CHEMICAL TECHNOLOGY (Gong, 2013)

Sulfuric Acid Industry

This example was used to illuminate the common composition of chemical engineering process (material preparation, material purification, chemical reaction, separation and refining of product, "three wastes" treatment), the involved unit operations and equipment.

Synthetic of Ammonia Industry

This example can not only be used to illuminate the general composition of chemical engineering process, unit operations and equipment, it can also show the concept of material balance, heat balance and energy conservation.

The fifth homework was taken as a course open-book examine. Students were asked to submit course paper within the appointed time, and the paper should include the following six parts: (1) chemical product design goal, significance, literature review (scored 30); (2) design contents and scope (scored 10); (3) production program and flow diagram (scored 20); (4) mass balance calculation for main equipment and process, equipment selection (scored 20); (5) heat balance calculation for main equipment and process, heat exchanger selection (scored 20); (6) references.

4. COURSE COMPREHENSIVE EVALUATION

The grade point average consists three parts: attendance (scored 10), regular grades and course paper. The regular grades are grading by the four times of homework, and it totally scored 30 in grade point average. The course paper in the fifth homework totally scored 60.

5. CONCLUSIONS

It has been testified by sets of teaching practice that the use of the above mentioned knowledge framework is beneficial to the students poor in basic knowledge of Chemical Engineering. Based on the study of Chemical Process and Equipment, students can get some understanding as follows: (1) Basic research in lab is very important because it is the foundation of chemical industry, but the results commonly cannot suit for large scale production. (2) Chemical production process is very complex, and selection of technological parameter, process and equipment should get through strict design, calculation, and even small experiment, medium experiment. (3) Chemical technological process includes series of unit operations and equipment concerning material preparation, material purification, chemical reaction, separation and refining of product, "three wastes" treatment. (4) As for chemical equipment, the mostly used design and calculation methods include material balance, energy (mechanical energy, heat energy) balance. Aspen Plus, ChemCAD, Design II, gPROMS, VMGSIM and ECSS are the commonly used software. (5) Ensuring economy, advancement and rationality are the most important designing principle.

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